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DESCRIPTION

DATA STORAGE MEDIUM, DATA RECORDING AND REPRODUCING METHOD, AND DATA RECORDING AND REPRODUCING APPARATUS

Technical Field

The present invention relates to a data storage medium to which files managed using a volume/file structure are recorded and reproduced, and in which the number of data recording operations to any same area is limited, and to a data recording and reproducing method and data recording and reproducing apparatus using this data storage medium. More particularly, the present invention relates to a data storage medium having a plurally recorded volume/file structure which is effective for improving the reliability of recorded data and in which address information indicative of an area that is not recorded when a volume/file structure or file is additionally written from one end of a data recording area, and address information indicative of invalid data that is additionally recorded before and after a file or volume/file structure in the data recording area but is not used for retrieving volume/file structure, are managed within a file structure; and relates further to a data recording and reproducing method and a data recording and reproducing apparatus which use this data storage medium.

Background Art

While media of various types have been used in recent years for recording digital data, the low-cost recordable optical disc medium known as CD-R in particular has rapidly become widespread. The multi-session method used for writing data to these CD-R discs is now well known. Data recording using this multi-session method is described next below with reference to accompanying figures.

Fig. 8 shows the data structure of a multi-session CD-R disc to which files managed using the volume/file structure defined in the ISO 9660 standard are recorded. Files and volume/file structure for managing the files are recorded in session units. Each session has a lead-in area, an inner link area, a user data area, and a lead-out area. It is to be noted that only the first session does not have a lead-in area. In addition, an outer link area is formed between sessions.

When recording a data session, a file and volume/file structure for managing the file are first recorded to the user data area. The lead-out area is then recorded. This lead-out area is recorded to make data reproduction easier on a CD-ROM drive, which is unable to detect an address from an unrecorded area on a CD-R disc because it is unable to detect the wobble address recorded to the CD-R disc. Data indicative of the address for a next session or user data area is then recorded to the lead-in area. A

run-in block and run-out block are additionally recorded at the beginning and end of each area when recording to the user data area, lead-in area, or lead-out area. The run-in and run-out blocks are also partially overwritten on disc, and these overwritten areas are referred to as link blocks. An inner link area comprising a run-out block, link block, and run-in block is thus formed between a lead-in area and user data area and between a user data area and lead-out area, and an outer link area having the same configuration is formed between a lead-out area and lead-in area.

Fig. 9 shows the directory structure used for managing files recorded to a CD-R disc in conjunction with the data structure shown in Fig. 8. The directory structure shown in Fig. 9 has a subdirectory (Dir-A) for managing a data file (File-a), a subdirectory (Dir-B) for managing a data file (File-b), and a subdirectory (Dir-C) for managing a data file (File-c) below the root directory. When data file (File-a), data file (File-b), and data file (File-c) are sequentially recorded during a first session, second session, and third session in accordance with this directory structure, the data structure described above with reference to Fig. 8 is formed on the CD-R disc.

Fig. 10 is a flow chart describing a recording operation for forming the data structure shown in Fig. 8 on a disc. The data recording operation performed each session is described next below according to the steps shown in this flow chart.

(S1001) When a CD-R disc is inserted into the disk

recorder, the disk recorder accesses the lead-in area reserved at a specific location at the inside circumference of the disc, and attempts to read the TOC data from this lead-in area. This TOC data is a table of contents for the data recorded on the data storage medium. If the TOC data is reproduced from the lead-in area, a step (S1002) for retrieving the following session data is performed. However, if the data could not be reproduced because the lead-in area is unrecorded, the session data recording operation is performed according to the procedure beginning in step (S1003).

(S1002) If the TOC data is reproduced from the lead-in area, the disk recorder reads the start address of the following session contained in this TOC data, returns to step (S1001), and then tries to reproduce data from the lead-in area of the following session.

(S1003) When a lead-in area to which no data is recorded is detected, the file recorded as the session data and the volume/file structure for managing said file are generated as follow.

First, when data is not reproduced from the lead-in area, the data file (File-a) to be recorded as the data for the first session, subdirectory (Dir-A) for managing data file (File-a), a directory file for managing the root directory, and a primary volume descriptor, path table, etc., as the volume/file structure for managing these files and the directory file, are generated according to the ISO 9660 standard.

If TOC data is reproduced from the lead-in area, the volume/file structure and directory file are read using the user data area start address contained in the most recently read TOC data. For example, with a disc to which only a first session has been recorded, data is read from user data area 802; with a disc to which a second session has also been recorded, data is read from user data area 805. The content of the volume/file structure is then updated by adding thereto the file newly recorded to the read data and a directory file for managing said file. For example, data file (File-b) and the subdirectory (Dir-B) for managing data file (File-b) are added to the data read from user data area 802 on a disc to which only a first session has been recorded, and a new volume/file structure is then generated; data file (File-c) and the subdirectory (Dir-C) for managing data file (File-c) are added to the data read from user data area 805 on a disc to which a second session has also been recorded, and a new volume/file structure is then generated.

(S1004) When the volume/file structure to be recorded to a user data area is generated, the lead-in area and run-out block of predetermined recording size are skipped, a predefined link block/run-in block and link block/run-out block are added before and after the recording data generated in step (S1003), and the recording data is continuously recorded.

(S1005) When recording data to the user data area is completed, recording data having a predefined link block/run-in

block and link block/run-out block added before and after the data recorded to the lead-out area is generated. The resulting recording data is then recorded continuously from the link block following the run-out block recorded in step (S1004). When recording the first session, for example, this operation records lead-out area 803 and the run-in block/link block and run-out block/link block located therebefore and thereafter. When recording a second session, this operation records lead-out area 806 and the run-in block/link block and run-out block/link block located therebefore and thereafter.

(S1006) When recording data to the lead-out area is completed, the start address for the next session is calculated with reference to the predefined outer link area recording size. The calculated start address of the next session is embedded with the start address of the user data area recorded in step (S1004) in the TOC data recorded to the lead-in area.

Recording data comprising predefined link block/run-in block and link block/run-out block before and after the recording data for the lead-in area is then generated. The resulting recording data is then recorded continuously from a specific position at the inside circumference of the disk if the first session is being recorded, and from the link block following the run-out block recorded in step (S1005) if a second or third session is being recorded. This recording data is recorded continuously. As a result of this recording operation, the lead-in area 801 at the most inside circumference and the run-out block/link block located immediately

thereafter are recorded in the recording operation for a first session, for example. In a recording operation for a second session, the lead-in area 804 and the run-in block/link block and run-out block/link block units positioned therebefore and thereafter are recorded, and the data recording operation ends.

The data recording operation described above forms a multi-session data structure such as shown in Fig. 8 on the disc. A logical sector number (LSN) is assigned to each sector in the data structure shown in Fig. 8 with the first sector in the user data area in the first session designated 0, and the logical sector number rising continuously at each successive sector. The volume space is defined as the area beginning from the sector at LSN 0.

The operation whereby a data file (File-a) reproduced from the first session of a disk having a data structure as shown in Fig. 8 is described next below with reference to Fig. 8 and Fig. 10.

When a CD-R disc is inserted to a disc reader, the disc reader follows the procedure shown in steps (S1001) to (S1003) in the flow chart in Fig. 10 to read the latest volume/file structure 820 from the user data area of the third session. If a CD-ROM drive is connected to a computer system, the host computer obtains the start address for the user data area of the third session to which the latest volume/file structure is recorded by executing READ TOC command. Using this start address, it then calculates the LSN of the sector to which the latest volume/file structure is recorded, and reads this structure from the disc.

Next, when the latest volume/file structure 820 is read, the structure is interpreted according to the ISO 9660 standard using the primary volume descriptor 821, path table 822, root directory 823, and directory file (Dir-A) 824 for managing data file (File-a) 825. The recording position of the data file is then read from the directory record of the data file (File-a) 825 contained in directory file (Dir-A) 824.

The data file (File-a) 825 recorded to the user data area of the first session is then reproduced based on said data file recording position.

Disclosure Of Invention

In order to find an unrecorded area of the medium or record or reproduce a data file and file management information for managing data files recorded to a multi-session data storage medium recorded as described above, TOC data recorded to a lead-in area inside and outside the volume space must be read using a special command such as the above-noted READ TOC command.

Furthermore, the lead-in area, lead-out area, inner link area, and outer link area are recorded in the volume space as invalid areas that cannot be used for retrieving the volume/file structure or recording data files. These areas are, however, not managed using the volume/file structure, and the volume space is thus managed as a noncontiguous space with inaccessible areas in

certain parts. This means that in data storage media having a disc area that can be rewritten a specific number of times or more, it is difficult to effectively use the lead-out area, lead-in area, inner link area, and outer link area, which have a large size of several megabytes or more, as file recording space.

The present invention solves this problem, and has as its object to provide a data storage medium whereby data files recorded to the medium and file management information for managing these data files can be recorded and reproduced and unrecorded areas can be retrieved using only the volume/file structure, and various areas where invalid data is recorded in the volume space can be reused. A further object of the present invention is to provide a data storage medium achieving a high reliability file structure by plurally recording file management information.

To achieve the above object, the present invention is a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, wherein start address information for an unrecorded area existing in a volume space is recorded in the volume space as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data storage medium for recording and reproducing a

file managed using a volume/file structure where a number of data recording operations to a same area is limited, wherein invalid data not used for retrieving volume/file structure is recorded added before and after volume/file structure and a data file; and invalid extent management information for managing an invalid data recording area is recorded in the volume space as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, wherein root directory file management information is plurally recorded as main chaining information and reserve chaining information; address information of an area where main chaining information and reserve chaining information are recorded at a beginning of a volume space is recorded as part of a file set descriptor; and address information of an area where main chaining information and reserve chaining information is update recorded is recorded as part of main chaining information and reserve chaining information.

Furthermore, to achieve the above object, the present invention is a data recording method for performing a formatting process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording step for recording start address

information for an unrecorded area existing in a volume space as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data recording method for performing a formatting process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording step for recording invalid data not used for retrieving volume/file structure added before and after volume/file structure and a data file, and recording invalid extent management information for managing an invalid data recording area as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data recording method for performing a formatting process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a file set information recording step for recording as part of a file set descriptor address information for an area where main chaining information and reserve chaining information are recorded at a beginning of a volume space; and chaining information recording step for plurally recording main chaining information and reserve chaining information having address information of an area where root directory file management information and main chaining information and reserve chaining information are update recorded.

Furthermore, to achieve the above object, the present invention is a data recording apparatus for performing a formatting process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording means for recording start address information for an unrecorded area existing in a volume space as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data recording apparatus for performing a formatting process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording means for recording invalid data not used for retrieving volume/file structure added before and after volume/file structure and a data file, and recording invalid extent management information for managing an invalid data recording area as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data recording apparatus for performing a formatting process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a file set information recording means for recording as part of a file set descriptor address information for an area where main chaining

information and reserve chaining information are recorded at a beginning of a volume space; and a chaining information recording means for plurally recording main chaining information and reserve chaining information having address information of an area where root directory file management information and main chaining information and reserve chaining information are update recorded.

Furthermore, to achieve the above object, the present invention is a data recording method for performing a file recording process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording step for recording start address information for an unrecorded area existing in a volume space as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data recording method for performing a file recording process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording step for recording invalid data not used for retrieving volume/file structure added before and after volume/file structure and a data file, and recording invalid extent management information for managing an invalid data recording area as part of root directory file management information.

Furthermore, to achieve the above object, the present

invention is a data recording method for performing a file recording process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a file set information reproducing step for reproducing address information of an area where main chaining information and reserve chaining information are recorded at a beginning of a volume space using a file set descriptor; a chaining information recording step for reproducing, using main chaining information or reserve chaining information, following main chaining information or reserve chaining information, or root directory file management information; and a chaining information recording step for plurally recording main chaining information and reserve chaining information having address information of an area where root directory file management information and main chaining information and reserve chaining information are update recorded.

Furthermore, to achieve the above object, the present invention is a data recording apparatus for performing a file recording process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording means for recording start address information for an unrecorded area existing in a volume space as part of root directory file management information.

Furthermore, to achieve the above object, the present

invention is a data recording apparatus for performing a file recording process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a chaining information recording means for recording invalid data not used for retrieving volume/file structure added before and after volume/file structure and a data file, and recording invalid extent management information for managing an invalid data recording area as part of root directory file management information.

Furthermore, to achieve the above object, the present invention is a data recording apparatus for performing a file recording process on a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a file set information reproducing means for reproducing address information of an area where main chaining information and reserve chaining information are recorded at a beginning of a volume space using a file set descriptor; a chaining information recording means for reproducing, using main chaining information or reserve chaining information, following main chaining information or reserve chaining information, or root directory file management information; and a chaining information recording means for plurally recording main chaining information and reserve chaining information having address information of an

area where root directory file management information and main chaining information and reserve chaining information are update recorded.

Furthermore, to achieve the above object, the present invention is a data recording reproducing method for performing a file reproducing process from a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a file set information reproducing step for reproducing address information for an area where main chaining information and reserve chaining information are recorded at a beginning of a volume space using a file set descriptor; and a chaining information recording step for reproducing, using main chaining information or reserve chaining information, following main chaining information or reserve chaining information, or root directory file management information.

Furthermore, to achieve the above object, the present invention is a data reproducing apparatus for performing a file reproducing process from a data storage medium for recording and reproducing a file managed using a volume/file structure where a number of data recording operations to a same area is limited, comprising: a file set information reproducing means for reproducing address information for an area where main chaining information and reserve chaining information are recorded at a beginning of a volume space using a file set descriptor; and a

chaining information recording means for reproducing, using main chaining information or reserve chaining information, following main chaining information or reserve chaining information, or root directory file management information.

Brief Description Of Drawings

Fig. 1 is a data structure diagram showing the area structures in a data storage medium according to a preferred embodiment of the present invention;

Fig. 2 is a block diagram of a data recording and reproducing apparatus medium according to a preferred embodiment of the present invention;

Fig. 3 is a flow chart describing a formatting process of a data recording and reproducing apparatus medium according to the present invention;

Fig. 4 is a data structure diagram of a formatted data storage medium;

Fig. 5 is a flow chart describing a file recording process of a data recording and reproducing apparatus according to the present invention;

Fig. 6 is a data structure diagram of a data storage medium after the file recording process;

Fig. 7 is a flow chart describing a file reproducing process of a data recording and reproducing apparatus according to the present invention;

Fig. 8 is a data structure diagram of a CD-R disc recorded with a conventional multi-session method;

Fig. 9 is a diagram of a directory structure for managing files on disc; and

Fig. 10 is a flow chart of a multi-session data recording operation.

Best Mode for Carrying Out the Invention

The preferred embodiments of the present invention are described below with reference to the accompanying figures.

The area structure of a data storage medium is described first below with reference to Fig. 1, and the data recording and reproducing apparatus is described with reference to the block diagram in Fig. 2. After then describing a process for formatting this data storage medium with reference to Fig. 3, and the file recording process shown in Fig. 5, the detailed data structure that is characteristic of a data storage medium according to the present invention is described. Finally, a process for reproducing files from this data storage medium is described with reference to Fig. 7.

A data storage medium for recording files managed with a volume/file structure as defined by the ISO 13346 standard using a data storage medium such as a CD-R disc or CD-RW disc to which the number of data recording operations to a same disc area is limited, and a data recording and reproducing method and data

recording and reproducing apparatus using this data storage medium, are described below as a preferred embodiment of the present invention with reference to the accompanying figures. It is to be noted that unless otherwise specifically noted, the various descriptors and pointers, etcetera, recorded to the data storage medium as the volume/file structure in the following description shall be those used in a data structure conforming to ISO 13346.

Fig. 1 is a data structure diagram showing the area structure written to a data storage medium according to this preferred embodiment of the invention. As shown in Fig. 1, the data recording area starts from lead-in area 101, and includes link area 102 and the volume space. The disk formatting process creates the following areas within the volume area: a main volume structure area 103 to which volume structure is recorded; the anchor point area 104; a reserve volume structure area 105 to which a copy of the volume structure is recorded; and anchor point area 106.

Following next with link extent 107, link extent 109, link extent 112, and finally link extent 114 disposed therebetween are formed a file set information area 108 for recording a file set descriptor according to the present invention, a main chaining information area 110 for recording root directory file management information, including link information according to the present invention, a reserve chaining information area 111 for recording a copy of the main chaining information, file structure area 113 containing a root directory file, anchor point area 115, and part of

overrun extent 116 including an overrun block.

Main chaining information area 117 for recording main chaining information of which the content is updated by sequentially recording data file (File-a) and data file (File-b) according to the directory structure shown in Fig. 9 and reserve chaining information area 118, and file structure/file area 120 containing data file (File-a) and file structure/file area 122 containing data file (File-b) with link extent 119 and link extent 121 disposed therebetween, are formed next. Next are formed link extent 123 and anchor point area 124, and part of overrun extent 125.

Main chaining information area 126 for recording main chaining information of which the content is updated by sequentially recording data file (File-c) based on the directory structure shown in Fig. 9 and reserve chaining information area 127, and file structure/file area 129 containing data file (File-c), are formed next with link extent 128 disposed therebetween. Next are formed link extent 130, anchor point area 131, and part of overrun extent 132.

The basic concept of the data structure of a data storage medium shown in Fig. 1 is described above. A more detailed data structure, including the data recording sequence, is described next below.

Fig. 2 is a block diagram of a data recording and reproducing apparatus according to a preferred embodiment of the

present invention. As shown in Fig. 2, this data recording and reproducing apparatus comprises: a system controller 201, memory circuit 202, I/O bus 203, magnetic disk drive 204, and optical disk drive 205.

The system controller 201, which is achieved with a microprocessor containing a control program and operating memory, comprises: volume structure recording means 211 for recording the volume structure; a volume structure reproducing means 212 for reproducing the volume structure; a file set information recording means 213 for recording the file set information; file set information reproducing means 214 for reproducing file set information; a file structure recording means 215 for recording the file structure; file structure reproducing means 216 for reproducing the file structure; a file recording means 217 for recording file data; a file reproducing means 218 for reproducing file data; chaining information recording means 219 for recording the chaining information; chaining information reproducing means 220 for reproducing the chaining information; lead-in area recording means 221 for recording data to the lead-in area; and overrun block recording means 222 for recording the overrun block and anchor volume descriptor pointer.

The memory circuit 202 comprises volume structure memory 231 for temporarily storing volume structure; file structure memory 232 for temporarily storing file structure; file set information memory 233 for temporarily storing file structure;

chaining information memory 234 for temporarily storing chaining information; file memory 235 for temporarily storing a data file; and overrun block memory 236 for temporarily storing data recorded for the anchor volume descriptor pointer and overrun extent.

The formatting procedure for a data storage medium according to the present invention is described next below with reference to the block diagram in Fig. 2, the flow chart of the formatting process in Fig. 3, and a diagram of the data structure resulting from this formatting process shown in Fig. 4.

(S301) When it is detected that a disk has been inserted to the optical disk drive 205, the system controller 201 instructs the optical disk drive 205 to record the lead-in area according to a control program stored as the lead-in area recording means 221. The optical disk drive 205 thus accesses a specific location at the inside circumference of the disk, and appends directly after the recorded data in the predefined lead-in area 101 a run-out block and link block of specific recorded content and size. When data recording to the lead-in area 101 and link area 102 is completed, the optical disk drive 205 notifies the system controller 201 that recording is over.

(S302) Based on a control program stored internally as volume structure recording means 211, the system controller 201 generates in the volume structure memory 231 of memory circuit 202 according to the data structure sequence shown in Fig. 4 a volume descriptor string that is recorded twice, to the main

volume structure area 103 and reserve volume structure area 105, and anchor volume descriptor pointer 409 and 410, which is recorded twice, to anchor point area 104 and 106, respectively. The volume descriptor string comprises an NSR descriptor 401, primary volume descriptor 402, Implementation use volume descriptor 403, partition descriptor 404, logical volume descriptor 405, unallocated space descriptor 406, terminating descriptor 407, and logical volume integrity descriptor 408. It should be noted that the anchor volume descriptor pointer 409 and 410 contains address information for the main volume structure area and the reserve volume structure area, and the anchor point area 104 and 106 to which these are recorded are assigned to a fixed location in the volume space.

Following this control program, the system controller 201 instructs the optical disk drive 205 to record the volume structure generated in the volume structure memory 231. The optical disk drive 205 then generates in the system controller 201 recording data having a predefined link block/run-in block and run-out block/link block added before and after the volume structure transferred from the volume structure memory 231, and records the recording data continuously from the link block of link area 102.

Recording the lead-in area and recording this volume structure overlap at the link block, and data is thus recorded twice to at least part of the link block. The method of recording data bracketing this link area is accomplished using the same

conventional control procedure.

When recording the volume structure is completed, the optical disk drive 205 notifies the system controller 201 that recording has ended.

(S303) Next, following a program stored internally as the file set information recording means 213, the system controller 201 generates file set information containing one or more successive file set descriptors 141 in the file set information memory 233. These file set descriptors 141 contain the address information of the main chaining information area 110 and reserve chaining information area 111 to which are recorded file entries 142 and 144 of the initially recorded root directory.

Then, based on this control program, the system controller 201 instructs the optical disk drive 205 to record the file set information generated in the file set information memory 233.

As in the volume structure recording operation, the optical disk drive 205 generates the recording data in the system controller 201 by adding a predetermined link block/run-in block and run-out block/link block before and after the file set information transferred from the file set information memory 233, and then continuously records the recording data from the link block of the link extent 107. When recording the file set information has been completed, the optical disk drive 205 notifies the system controller 201 that recording has ended.

(S304) Next, following a program stored internally

as the file structure recording means 215, the system controller 201 generates a root directory file, that is, file structure, in the file structure memory 232 of memory circuit 202.

Then, following this control program, the system controller 201 instructs the optical disk drive 205 to record the file structure generated in the file structure memory 232. The system controller 201 specifies in this recording command the start address of the file structure area 113 to which the root directory file 146 is recorded with consideration for the recording size of the fixed-length main chaining information area 110 and reserve chaining information area 111, and fixed-length link extent 109 and 112, inserted between the previously recorded file set information area 108 and file structure area 113.

As in the recording operation of the volume structure, the optical disk drive 205 generates in the system controller 201 recording data having a predetermined link block/run-in block and run-out block/link block added before and after, respectively, the file structure transferred from the file structure memory 232, and continuously records this recording data from the link block of link extent 112. When recording the file structure is completed, the optical disk drive 205 notifies the system controller 201 that recording has ended.

(S305) Next, following a program stored internally as the overrun block recording means 222, the system controller 201 generates a anchor volume descriptor pointer 411 containing

address information for the main volume structure area 103 and reserve volume structure area 105, and data for recording to the overrun block following the pointer 411, in the overrun block memory 236.

Then, following this control program, the system controller 201 instructs the optical disk drive 205 to record the anchor volume descriptor pointer 411 and following overrun block generated in the overrun block memory 236.

As in the recording operation of the volume structure, the optical disk drive 205 generates in the system controller 201 recording data having a predetermined link block/run-in block and run-out block/link block added before and after, respectively, the anchor volume descriptor pointer 411 and following overrun block transferred from the overrun block memory 236, and continuously records this recording data from the link block of link extent 114. When recording the anchor volume descriptor pointer 411 and following overrun block is completed, the optical disk drive 205 notifies the system controller 201 that recording has ended.

(S306) Finally, following a program stored internally as the chaining information recording means 219, the system controller 201 generates chaining information in the chaining information memory 234 of the memory circuit 202.

This chaining information is information for managing the root directory file using an Information Control Block (ICB) as defined in ISO 13346, and comprises file entries 142 and 144 for

root directory, and indirect entries 143 and 145, recorded to the main chaining information area 110 and reserve chaining information area 111. The indirect entries 143 and 145 of this chaining information contain the start address information of the unrecorded area of the volume space that is used for updating new chaining information; the file entries 142 and 144 contain address information for invalid extents, that is, areas such as the overrun extent and link extents to which invalid data not used for retrieving the volume and file structure is recorded. The structure of this chaining information is described in further detail below.

Then, following this control program, the system controller 201 instructs the optical disk drive 205 to record the chaining information generated in the chaining information memory 234.

The system controller 201 specifies the start address of the main chaining information area 110 in this recording command with consideration given to the recording position of the file set information area 108 and the recording size of the fixed-length link extent 109.

As in the recording operation of the volume structure, the optical disk drive 205 generates in the system controller 201 recording data having a predetermined link block/run-in block and run-out block/link block added before and after, respectively, chaining information and reserve chaining information transferred from the chaining information memory 234, and continuously

records this recording data from the link block of link extent 109. When recording the chaining information is completed, the optical disk drive 205 notifies the system controller 201 that recording has ended.

When the above-described formatting process is completed, a data structure as shown in Fig. 4 is formed on the data storage medium. It should be noted that the arrows (S301) to (S306) added to Fig. 4 indicate the area recorded in each step shown in Fig. 3. It should be further noted that the overrun block recorded in step (S305) is, like the lead-out area noted in the description of the related art, recorded to prevent an overrun into an unrecorded area when a disk reproducing device that is incapable of detecting location from a unrecorded area accesses, for example, file structure area 113 or anchor point area 115.

It should be further noted that the lead-in area 101, main volume structure areas 103, 104, 105, 106, file set information area 108, chaining information areas 110 and 111, file structure area 113, anchor point area 115, and the following overrun extent 116 have been described in the above formatting process as being separately recorded in conformance to the command unit processing sequence of a computer system. However, if a dedicated recording device that is not dependent upon the architecture of a computer system is used, it is also possible to perform all or part of these formatting steps continuously. For example, in a simplified formatting process in

which recording operations for the lead-in area 101, volume structure areas 103, 104, 105, 106, file set information area 108, chaining information areas 110 and 111, file structure area 113, anchor point area 115, and following overrun extent 116 are performed continuously, link area 102 and link extents 107, 109, 112, and 114 shown in Fig. 4 do not exist.

In addition, the volume structure is recorded twice, to main volume structure area 103 and to reserve volume structure area 105, the chaining information is recorded twice, to main chaining information area 110 and to reserve chaining information area 111, and the file set descriptor is plurally recorded to the file set information area 108, in the present embodiment. In a data storage medium such as a DVD disc in which ECC blocks, the error correction unit, are built from a plurality of sectors, plurally recording across a plurality of ECC blocks is important for improving data reliability. For example, the reserve volume structure area 105 and anchor point area 106 are recorded to ECC blocks different from that to which the main volume structure area 103 and anchor point area 104 are recorded. In this type of recording operation, padding data is appropriately recorded so that the border between anchor point area 104 and reserve volume structure area 105 matches the ECC block boundary.

A procedure for controlling a process for recording files to a data storage medium according to the present invention is

described next with reference to the block diagram in Fig. 2, the diagram shown in Fig. 4 of a data structure resulting from the formatting process, the flow chart of this file recording process shown in Fig. 5, and the diagram shown in Fig. 6 of the data structure after file recording. It should be noted that data file (File-a) and data file (File-b) to be recorded in this file recording process are assumed to have already been transferred from the magnetic disk drive 204 to file memory 235, and are separately recorded according to the directory structure shown in Fig. 9.

(S501) Based on a control program stored internally as volume structure reproducing means 212, the system controller 201 instructs the optical disk drive 205 to reproduce the anchor volume descriptor pointer 409 recorded to anchor point area 104 at a specific logical sector number. The optical disk drive 205 accesses an area specified on the inserted disc (not shown in the figure) to read the anchor volume descriptor pointer 409, and transfers the information to the volume structure memory 231 of memory circuit 202. It should be noted that when the anchor volume descriptor pointer 409 cannot be reproduced, an operation for reproducing the anchor volume descriptor pointer 410 recorded to anchor point area 106 at a specific logical sector number is performed.

Next, the system controller 201 interprets the address information of the main volume structure area 103 contained in the read anchor volume descriptor pointer 409, and instructs the

optical disk drive 205 to read out data from main volume structure area 103. The optical disk drive 205 thus accesses the specific area, and sequentially reads and transfers to the volume structure memory 231 of memory circuit 202; the NSR descriptor 401, the primary volume descriptor 402, implementation use volume descriptor 403, partition descriptor 404, logical volume descriptor 405, unallocated space descriptor 406, terminating descriptor 407, and logical volume integrity descriptor 408. It should be noted that if it is not possible to reproduce data from the main volume structure area 103, the address information is interpreted for reserve volume structure area 105 contained in the anchor volume descriptor pointer 409, and an operation for reproducing the volume structure from the reserve volume structure area 105 is performed.

The system controller 201 also interprets this read volume structure to obtain the address information for the file set information area 108 to which the file set descriptor 141 is recorded.

(S502) Based on a control program stored internally as file set information reproducing means 214, and similarly to the volume structure reproducing operation, the system controller 201 instructs the optical disk drive 205 to reproduce the file set descriptor 141 recorded to file set information area 108. The optical disk drive 205 thus accesses the specified area to read the file set descriptor 141 and transfer it to the file set information

memory 233.

Next, the system controller 201 interprets the file set descriptor 141 to obtain the address information for the main chaining information area 110 and reserve chaining information area 111. It should be noted that the detailed data structure for this file set descriptor is further described below.

(S503) Based on a control program stored internally as chaining information reproducing means 220, the system controller 201 instructs a reproduction operation for the chaining information from the following main chaining information area using the address obtained from step (S502) or the following step (S504). The optical disk drive 205 then tries to reproduce data from the specified main chaining information area. If data is reproduced from the specified main chaining information area, the optical disk drive 205 transfers the reproduced chaining information to the chaining information memory 234.

The system controller 201 then performs step (S504) to retrieve the updated chaining information. It should be noted that if normal data reproduction is not possible because of an ECC error, for example, even though data is recorded to the main chaining information area, the system controller 201 instructs to reproduce the chaining information from the reserve chaining information area using a previously obtained address. If data is then reproduced from the specified reserve chaining information area, the optical disk drive 205 transfers the reproduced chaining information to the

chaining information memory 234.

If data reproduction is not possible because the specified main chaining information area and reserve chaining information area are unrecorded, the data reproduced last is determined to be the latest chaining information, and operation continues from step (S505). For example, the information reproduced from main chaining information area 110 or reserve chaining information area 111 is the latest chaining information if the data storage medium has only been formatted as shown in Fig. 4, and file entry 142 or 144 contained therein is used in the following procedure for root directory file management. If the data storage medium is as shown in Fig. 6 as a result of file recording, the information read from main chaining information area 117 or reserve chaining information area 118 is the latest chaining information, and file entry 147 or 149 contained therein is used in the following procedure for root directory file management.

(S504) Based on a control program stored internally as chaining information reproducing means 220, the system controller 201 obtains the address information of the following chaining information area from an indirect entry contained in the chaining information read in step (S503). For example, if the data storage medium is as shown in Fig. 6 as a result of file recording, the address information for the next unrecorded chaining information area is obtained from indirect entry 148 or 150 contained in the chaining information read from main chaining

information area 117 or reserve chaining information area 118. It should be noted that the detailed data structure of this indirect entry is further described below.

(S505) Based on a control program stored internally as file structure reproducing means 216, the system controller 201 obtains the address information for the area to which the root directory file is recorded from the file entry contained in the chaining information reproduced in step (S503). For example, if the data storage medium has only been formatted as shown in Fig. 4, the address information of root directory file 146 is obtained from the file entry 142 or 144 read from main chaining information area 110 or reserve chaining information area 111. If the data storage medium is as shown in Fig. 6 as a result of file recording, the address information for root directory file 160 is obtained from the file entry 147 or 149 read from main chaining information area 117 or reserve chaining information area 118.

Next, the system controller 201 instructs reproducing the root directory file 146 or root directory file 160 from file structure area 113 or file structure/file area 122 using the obtained address information. The optical disk drive 205 then reproduces the latest root directory file from the specified area and transfers it to the file structure memory 232. For example, if the data storage medium has only been formatted as shown in Fig. 4, the root directory file 146 recorded to file structure area 113 is read. If the data storage medium is as shown in Fig. 6 as a result of file

recording, root directory file 160 recorded to file structure/file area 122 is reproduced. When reproducing the root directory file thus ends, the optical disk drive 205 notifies the system controller 201 that root directory file reproduction is completed.

(S506) Based on a control program stored internally as file structure recording means 215, the system controller 201 generates a directory file (Dir-A) 153 for managing data file (File-a) 151, and file entry (File-a) 152 and file entry (Dir-A) 154 for managing these files, and updates the content of the root directory file stored into file structure memory 232 in step (S505). Then, with the directory files and file entries stored to file structure memory 232, and data file (File-a) transferred from the magnetic disk drive 204 and stored in file memory 235, the system controller 201 instructs the optical disk drive 205 to record the data according to a control program stored internally as file structure recording means 215 and file recording means 217.

The system controller 201 specifies the start address of the recording area of the data file and file structure in this recording operation command based on the recording size of the fixed length main chaining information area 117 and reserve chaining information area 118 and the fixed-length link extent, allocated between the overrun extent 116 and file structure/file area 120. The optical disk drive 205 generates the recording data in the system controller 201, by adding a predefined link block/run-in block and run-out block/link block before and after the data file

(File-a) transferred from the file memory 235 and the file structure, including the directory file and file entry, transferred from the file structure memory 232 and recorded after data file (File-a), and then records continuously from the link block of the link extent 119. When this data recording to the file structure/file area 120 ends, the optical disk drive 205 notifies the system controller 201 that recording has ended. As a result of the above described recording operation, data file (File-a) 151 and a file entry 152 for managing it, directory file (Dir-A) 153 and a file entry 154 for managing it, and an updated root directory file 155, are formed in the file structure/file area 120 as shown in Fig. 6.

(S507) To additionally record a new data file (File-b), the system controller 201 follows the same control procedure as step (S506) to record data file (File-b) 156 previously transferred from magnetic disk drive 204 to file memory 235, and file structure for managing data file (File-b) 156, to file structure/file area 122. When this file recording operation is completed, data file (File-b) 156 and file entry 157 for managing it, directory file (Dir-B) 158 and file entry 159 for managing it, and an updated root directory file 160, are formed in file structure/file area 122 as shown in Fig. 6.

(S508) The system controller 201 performs the same procedure shown in step (S305) of the formatting process described above to record to the anchor point area 124 and overrun extent 125.

(S509) The system controller 201 performs the

same procedure shown in step (S306) of the formatting process described above to record chaining information to the main chaining information area 117 and reserve chaining information area 118, and the file recording operation then ends.

A data structure as shown in Fig. 6 is formed on the data storage medium by performing the file recording process described above. It should be noted that the arrows (S506) to (S509) added to Fig. 6 indicate the area recorded in each step shown in Fig. 5. It should be further noted that the overrun block recorded in step (S508) is, like the lead-out area noted in the description of the related art, recorded to prevent an overrun into a unrecorded area when a disk reproducing device that is incapable of detecting a location from unrecorded area accesses, for example, file structure/file area 122 or anchor point area 124.

Furthermore, the data file, directory file, and file entries for managing these are described as being recorded at once in step (S506) and step (S507), but these files and file entries can be recorded separately. When separately recorded, a link block/run-in block and run-out block/link block are recorded before and after the files or file entries, and a link extent is thus formed between files or file entries.

Because recording location of the data files and directory files recorded to file structure/file area 120 or 122, and file entries for managing the same, is logically managed based on

the file structure, the recording sequence of the data file or directory file and the file entry for managing the same shall not be limited to that shown in the data structure diagram in Fig. 6.

Furthermore, when a data file (File-c) as shown in the directory structure shown in Fig. 9 is newly recorded to a data storage medium having a data structure as shown in Fig. 6 using the same file recording procedure shown in the flow chart in Fig. 5, a data structure as shown in Fig. 1 is formed on the data storage medium.

The data structure of the file set descriptor 141 that is characteristic of the present invention is described in detail next below with reference to Fig. 1.

The file set descriptor is data for managing sets of files recorded within the volume space, and contains the address information of the area where the root directory file ICB was recorded during the formatting process. A conventional file set descriptor records the address information for one ICB for managing the root directory, but the file set descriptor 141 recorded in step (S303) in the formatting process shown in Fig. 3 stores address information for the main chaining information area 110 and reserve chaining information area 111 where the file entries 142 and 144 are recorded for managing the root directory file 146 recorded during the formatting process.

As shown in the file set descriptor 141 recorded to file

set information area 108 in Fig. 1, the specific data structure of the file set descriptor includes a descriptor tag 171, the length 172 of the main chaining information area and the reserve chaining information area, address information 173 for the main chaining information area 110, and address information 174 for the reserve chaining information area 111.

One or more consecutive file set descriptors is recorded to the file set information area 108. In a data storage medium such as a DVD disc in which ECC blocks, the error correction unit, are built from a plurality of sectors, plurally recording across a plurality of ECC blocks is important for improving data reliability. Data reliability is improved, for example, by allocating two or more ECC blocks as the file set information area 108, and recording multiple file set descriptors to this area.

The data structure of the main chaining information and reserve chaining information that are characteristic of the present invention is described in detail next below with reference to Fig. 1.

The main chaining information and reserve chaining information are a functional extension of the above-noted root directory file ICB using ICB strategy type 4096 specified in the ISO 13346 standard, and store a file entry and indirect entry. The main chaining information and reserve chaining information are recorded in step (S306) of the formatting process shown in Fig. 3 and step (S509) of the file recording procedure shown in Fig. 5.

In general, an indirect entry is a pointer to another ICB, and an indirect entry in the present invention is extended to manage address information for the main chaining information and reserve chaining information updated during file recording. As for the specific data structure of an indirect entry, the indirect entry 148 shown in Fig. 1 contains a descriptor tag 175 for identifying the descriptor as an indirect entry, the length 176 of the main chaining information area and the reserve chaining information area, address information 177 for the main chaining information area 126, and address information 178 for the reserve chaining information area 127. The indirect entry 162 recorded to main chaining information area 126 contains address information (186, 187) indicating the recording area of the main chaining information and reserve chaining information which are updated tounrecorded area 133 in conjunction with recording a new file. The address information 186 for recording area of updated main chaining information is simultaneously interpreted as the start address of the unrecorded area 133.

A file entry contained in the main chaining information and reserve chaining information is generally root directory management information. A file entry according to the present invention, however, is extended to also register management information for invalid extents that are not used for retrieving the volume/file structure, such as overrun extents and link extents in the volume space. As a specific data structure of a file entry, a file

entry 161 shown in Fig. 1 contains a descriptor tag 179 for identifying the descriptor as a file entry; an allocation descriptor 180 with address information for the root directory file 165; an allocation descriptor 181 with address information for the link extent 128; an allocation descriptor 182 with address information for link extent 130; and an allocation descriptor 183 with address information for overrun extent 132.

It should be noted that file entry 161 as described above contains allocation descriptors for managing link extent 128, link extent 130, and overrun extent 132 as invalid extents. These invalid extents are newly allocated in conjunction with the recording operation for data file (File-c), and are located after main chaining information area 126 in Fig. 1. Another method, however, registers all link extents and overrun extent in the volume space as invalid extents in file entry 161. Furthermore, invalid extents are managed as part of the root directory file management information, in this preferred embodiment of the invention, but it is alternatively possible to manage a set of invalid extents as a special file by the normal file structure.

By managing invalid extents present in the volume space using a file structure as described above, the present invention can use a large size, i.e., plural megabytes or more, of overrun extents to perform a file append or file update recording operation within the normal file system management structure when the data storage medium enables overwriting a specific number of

times or more to a same disc area, such as is possible with a CD-RW disc. By having such functionality, a large size of invalid extents can be used effectively, and the volume space can be efficiently used. For example, in the data storage medium having a data structure as shown in Fig. 1, overrun extents 116 125, and 132 recorded for the purpose of preventing overruns into unrecorded disc areas are areas that lose their purpose when a new file is recorded. By managing these areas as part of the the file structure, however, it is possible to use these overrun extents as new file recording areas so that they do not completely lose functionality.

By extending the data structure of the file set descriptor, and newly introducing main chaining information and reserve chaining information extending the ICB for managing the root directory file as described above, the present invention significantly improves the reliability of the root directory file management information, which is extremely important as a file structure. For example, in Fig. 1 the file set descriptor 141 contains addresses for both the main chaining information area 110 and reserve chaining information area 111 in which the root directory file ICB is recorded twice. In the event that data cannot be reproduced from the main chaining information area 110 due to a disc scratch or soiling, for example, the root directory file ICB can be reproduced from the reserve chaining information area 111 by accessing the address information 174 for the reserve chaining

information area registered in the file set descriptor 141 as part of a recovery process. The indirect entries 148 and 150 recorded to main chaining information area 117 and reserve chaining information area 118 likewise contain address information for both the main chaining information area 126 and reserve chaining information area 127. If data reproduction from main chaining information area 126 is not possible due to a disc scratch or soiling, for example, a recovery process can reproduce file entry 161 and indirect entry 162 of the root directory file from the reserve chaining information area 127 by using the address information 178 of the reserve chaining information area registered in the indirect entry 148 or 150.

By thus recording file management information necessary for accessing the root directory file a plurality of times as described above according to this preferred embodiment of the present invention, the reliability of the file management information can be significantly improved.

It should be noted that in the above preferred embodiment of the present invention only the root directory file management information is recorded twice. However, by functionally extending the ICB for managing subdirectory files and data files, it will be obvious that the reliability of the corresponding file management information can also be improved.

It should be noted that while a single reserve chaining information area is recorded immediately after the main chaining

information area in the above description, the reserve chaining information area can be recorded at a location separated from the main chaining information area. Moreover, reliability can be further improved by allocating a plurality of reserve chaining information areas.

A control procedure for a file reproduction process applicable to a data storage medium according to the present invention is described next with reference to the block diagram shown in Fig. 2, the data structure diagram in Fig. 1, and the flow chart of a file reproduction process shown in Fig. 7. It should be noted that in this file recording process, data file (File-a) managed using the directory structure shown in Fig. 9 is reproduced.

(S701) As in step (S501) of the file recording process, the system controller 201 interprets the volume structure reproduced from main volume structure area 103 or reserve volume structure area 105, and obtains the address information for the file set information area 108 to which file set descriptor 141 is recorded.

(S702) As in step (S502) of the file recording process, the system controller 201 reproduces and interprets the file set descriptor 141 from file set information area 108 to obtain the address information for the main chaining information area 110 and reserve chaining information area 111 to which are recorded file entry 142 or 144 for the root directory file.

(S703) As in step (S503) of the file recording process, the system controller 201 tries to reproduce the chaining information from the following main chaining information area using the address information obtained in step (S702) or step (S704) described below. If the data is reproduced in this step, the system controller 201 performs step (S704) for retrieving the updated chaining information. If data is not normally reproduced from the main chaining information area because of an ECC error, for example, the system controller 201 tries to reproduce the chaining information from the following reserve chaining information area.

On the other hand, if data is not reproduced because both the specified main chaining information area and reserve chaining information area are not recorded, the system controller 201 decides that the last reproduced data is the latest chaining information, and continues the process from step (S705).

(S704) As in step (S504) of the file recording process, the system controller 201 obtains the address information of the following chaining information area from the indirect entry included in the chaining information as reproduced.

(S705) As in step (S505) of the file recording process, the system controller 201 reproduces the root directory file 165 according to the allocation descriptor 180 contained in file entry 161 or 163 for the root directory contained in the latest chaining information. Next, the system controller 201 sequentially reproduces file entry 154 for directory file (Dir-A), directory file

(Dir-A) 153, file entry 152 for data file (File-a), and finally data file (File-a) 151 starting from root directory file 165 to complete the file reproduction operation.

It will be obvious that the above described file reproduction operation is the same for data file (File-b) and data file (File-c). The file reproduction operation of the present invention can thus retrieve all data files using only the volume structure and file structure recorded in the volume space. A special command such as a READ TOC command for accessing this lead-in area is therefore not necessary because it is not necessary as described in the prior art to reproduce TOC data recorded to a lead-in area to which a logical sector number is not assigned as part of the file storage information. It is therefore possible to simplify the software used for managing the file system of this type of data storage medium in a personal computer system, and the software for controlling the interface of an optical disk drive, because all files can thus be reproduced using only the READ command used for data reproducing operations in the volume space.

By recording start address information for unrecorded areas existing in the volume space as chaining information recorded in the volume space, data files and file structure for managing these data files can be recorded and reproduced using only data recorded in the volume space of a data storage medium according to the present invention.

Furthermore, by managing as invalid extents data recording areas such as overrun extents that are not used for retrieving the volume/file structure, all allocated areas within the volume space can be managed by file structure in a data storage medium according to the present invention. Therefore, if in the data storage medium the number of times for recording data to a same area is limited, large size overrun extents occupying several megabytes or more can be used effectively as file recording areas, and the volume space can therefore be used efficiently and without waste.

Moreover, by extending the ICB data structure for managing file set descriptors and the root directory file and plurally recording file management information, a data storage medium according to this preferred embodiment of the present invention can significantly improve the reliability of file management information even when part of an area to which the file management information is recorded cannot be reproduced.